

*User Manual*  
**LaserCam-HR™**  
*Beam Diagnostics Digital CMOS Camera*  
**USB 2.0**





*User Manual  
LaserCam-HR  
Beam Diagnostics Digital  
CMOS Camera  
USB 2.0*



27650 SW 95th Ave.  
Wilsonville, OR 97070

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### **Technical Support**

#### **In the U.S.:**

Should you experience difficulties with your product, or need technical information, please visit our website: [www.Coherent.com](http://www.Coherent.com). You can obtain additional support by either telephoning our Technical Support Hotline at 1.800.343.4912, or e-mailing our Support Team at [support.instruments@Coherent.com](mailto:support.instruments@Coherent.com). Telephone coverage is available Monday through Friday (except U.S. holidays).

If you call outside our office hours, your call will be taken by our answering system and will be returned when the office reopens.

If there are technical difficulties with your product that cannot be resolved by support mechanisms outlined above, please

e-mail or telephone Coherent Technical Support with a description of the problem and the corrective steps attempted. When communicating with our Technical Support Department, via the web or telephone, the model and serial number of the product will be required by the Support Engineer responding to your request.

**Outside the U.S.:**

If you are located outside the U.S., visit our website for technical assistance, or telephone our local Service Representative. Representative phone numbers and addresses can be found on the Coherent website: [www.Coherent.com](http://www.Coherent.com).

Coherent provides web and telephone technical assistance as a service to its customers and assumes no liability thereby for any injury or damage that may occur contemporaneous with such services. These support services do not, under any circumstances, affect the terms of any warranty agreement between Coherent and the buyer. Operating a Coherent product with any of its interlocks defeated is always at the operator's risk.



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## *Preface*

This manual contains user information for the LaserCam-HR™ Beam Diagnostics Digital CMOS camera.

## *RoHS Compliance*

Effective 11/2006, this Coherent product was released as RoHS-compliant. If you purchased your product prior to 11/2006, contact Coherent Technical Support to determine the appropriate part numbers for your product. You can locate the date of manufacturing for your product on the serial number label.

## *U.S. Export Control Laws Compliance*

It is the policy of Coherent to comply strictly with U.S. export control laws.

Export and re-export of lasers manufactured by Coherent are subject to U.S. Export Administration Regulations, which are administered by the Commerce Department. In addition, shipments of certain components are regulated by the State Department under the International Traffic in Arms Regulations.

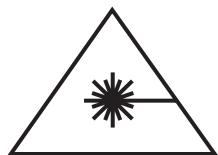
The applicable restrictions vary depending on the specific product involved and its destination. In some cases, U.S. law requires that U.S. Government approval be obtained prior to resale, export or re-export of certain articles. When there is uncertainty about the obligations imposed by U.S. law, clarification should be obtained from Coherent or an appropriate U.S. Government agency.

## ***Publication Updates***

To view information that may have been added or changed since this publication went to print:

1. Connect to [www.Coherent.com](http://www.Coherent.com).
2. Type **LaserCam-HR** in the Site Search box (top left of the screen) and then click the “>>” button.

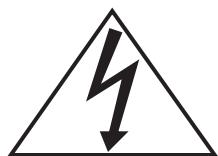
## ***Symbols Used in This Document***



---

**This symbol is intended to alert the operator to the presence of exposure to hazardous visible and invisible laser radiation.**

---



---

**This symbol is intended to alert the operator to the presence of dangerous voltages associated with the product that may be of sufficient magnitude to constitute a risk of electrical shock.**

---



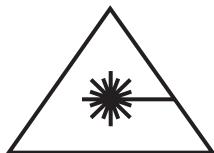
---

**This symbol is intended to alert the operator to the presence of important operating and maintenance instructions.**

---

# SAFETY

Carefully review the following safety information to avoid personal injury and to prevent damage to this instrument or any sensor connected to it. This equipment contains no user-serviceable parts. For service information, refer to “Obtaining Service” on page 22.



---

**The use and measuring of lasers is potentially dangerous. This instrument operates over wavelengths that include non-visible laser emissions.**

---

Proper laser operating practice in accordance with manufacturer recommendations is vital.

Eyewear and other personal protective equipment must be used in accordance with applicable laws and regulations.

If in doubt of correct operating procedures, consult the laser manufacturer and your laser safety officer.

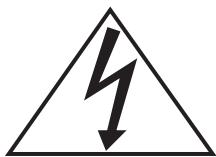
The equipment is not for use in critical medical environments.



---

**Do not operate the camera if its panels are removed or any of the interior circuitry is exposed.**

---



---

**Do not operate the camera in wet or damp conditions, or in an explosive atmosphere.**

---



---

**Operate the camera only within the specified voltage range.**

---



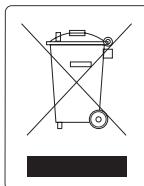
---

**Do not operate the camera if there are suspected failures. Refer damaged equipment to qualified Coherent service personnel.**

---

## *Waste Electrical and Electronic Equipment (WEEE, 2002)*

The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) is represented by a crossed-out garbage container label. The purpose of this directive is to minimize the disposal of WEEE as unsorted municipal waste and to facilitate its separate collection.



**Figure 1. Waste Electrical and Electronic Equipment Label**

## *Declaration of Conformity*

D121452

Revision AA

# **Declaration of Conformity**

We

Coherent, Inc.  
7470 SW Bridgeport Road  
Portland, Oregon, USA 97224

declare under sole responsibility that the

**LaserCam-HR**

meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility.  
Compliance was demonstrated per testing to EN61326 Electromagnetic  
Compatibility Product Family Standard for Measurement, Control and Laboratory  
Equipment to include the following test specifications as of June 2005:

EN55011 Class A Radiated Emissions

EN61000-4-2 Electrostatic Discharge – Performance Criteria C

Degradation of performance allowed during and after application of EMC phenomena as long as the  
operator may get the equipment functional without replacement of damaged parts..

EN61000-4-3 Radiated Immunity – Performance Criteria A

  
\_\_\_\_\_  
John H. Soller

Director of Engineering

  
\_\_\_\_\_  
Russ Vanluff

Site Manager

Date: 7/19/05

Date: 7-19-05

*LaserCam-HR User Manual*

# DESCRIPTION

The LaserCam-HR™ Beam Diagnostics Digital CMOS camera utilizes a laser grade  $\frac{2}{3}$ -inch progressive scan CMOS sensor for detection and analysis of laser beam profiles from 270  $\mu\text{m}$  to 5.5 mm in diameter with 6.7  $\mu\text{m}$  by 6.7  $\mu\text{m}$  spatial resolution over the spectral range of 300 to 1100 nm. LaserCam-HR characteristics include excellent signal-to-noise ratio and linear response for accurate beam dimension and uniformity measurements, and high overexposure protection for distortion-less measurements of saturated beam profiles. Other features include:

- USB 2.0 digital interface
- Compact design minimizes space required in optical train
- Mountable in any orientation for maximum flexibility. Camera markings provide for X, Y, and 38.6° alignments.
- Uses a single interface cable for data and power
- A Low Distortion Faceplate (LDFP) that minimizes room light, protects the CMOS array, and provides laser grade quality attenuation of 2500:1
- High sensitivity and dynamic range
- No lag, geometric distortion, or image burn-in



- Accepts C-mount optics, including all Coherent optical sampling, attenuation, and UV conversion accessories.
- High resolution: 1280 x 1024 active picture elements (pixels)
- Requires only USB 2.0 connections
- CE compliant when used with a CE-compliant computer and cables

## ***Parts and Accessories List***

Table 1 lists the orderable parts for the LaserCam-HR system.

***Table 1. Parts and Accessories List***

ITEM	PART NUMBER
LaserCam-HR System (RoHS)	1098577
Low Distortion Face Plate (LDFP)	1127133
Trigger In and Pass/Fail Output Cable (RoHS)	1120313
USB Cable, 3.0 meters (RoHS)	1114614
LaserCam-HR Shipping Container	1073686
LaserCam-HR User Manual (this document)	1126917

# SETUP

This section discusses the following topics:

- Software installation (this page)
- Cabling (page 8)
- Mounting the camera (page 9)

## *Software Installation*

For complete software installation instructions, refer to the *BeamView-USB With LaserCam-HR Quick Start Guide* (1086147) that shipped with your product. To view that document online:

1. Connect to our website: [www.Coherent.com](http://www.Coherent.com).
2. Type **LaserCam-HR** in the Site Search box (top left of the screen) and then click the “>>” button.
3. Click the “LaserCam-HR” link in the list of search results.
4. Click the “BeamView-USB With LaserCam-HR Quick Start Guide” link (bottom of the page, under the “Literature & Documentation” heading).
5. If the Download Request form appears (which only happens the first time you visit our website and request literature), fill in the information and then click the “Submit” button at the bottom of the form.

## ***Cabling***

Place the LaserCam-HR at the location where the beam will be measured. To protect the faceplate from dust, leave the dust cap installed until ready to make measurements.

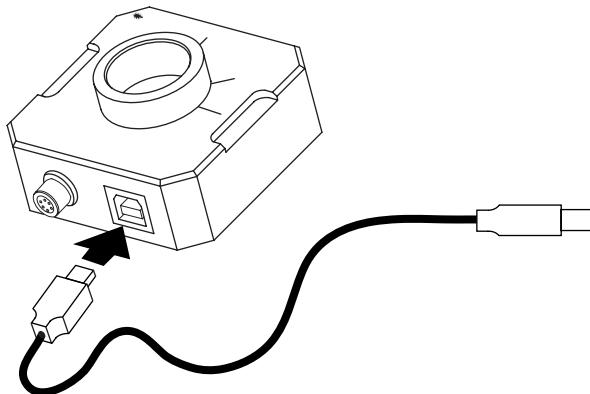
### **USB Cable**

Connect the USB 2.0 cable to the USB 2.0 connector on the LaserCam-HR camera (see Figure 2).

---

**Do not connect the USB cable to the computer until instructed to do so.**

---



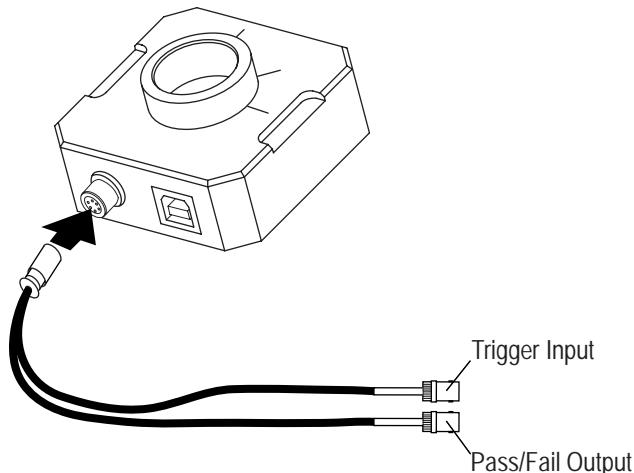
***Figure 2. USB Cable***

LaserCam-HR produces a standard UB 2.0 digital signal. It will interface through the USB 2.0 connector of any compatible PC using Coherent BeamView Version 4.3 software.

Connecting the Trigger and Pass/Fail cable is discussed next.

## Trigger Input and Pass/Fail Output Cable

For detailed information about the Trigger Input and Pass/Fail Output cable (1120313) shown in Figure 3, refer to the BeamView-USB software Help file.

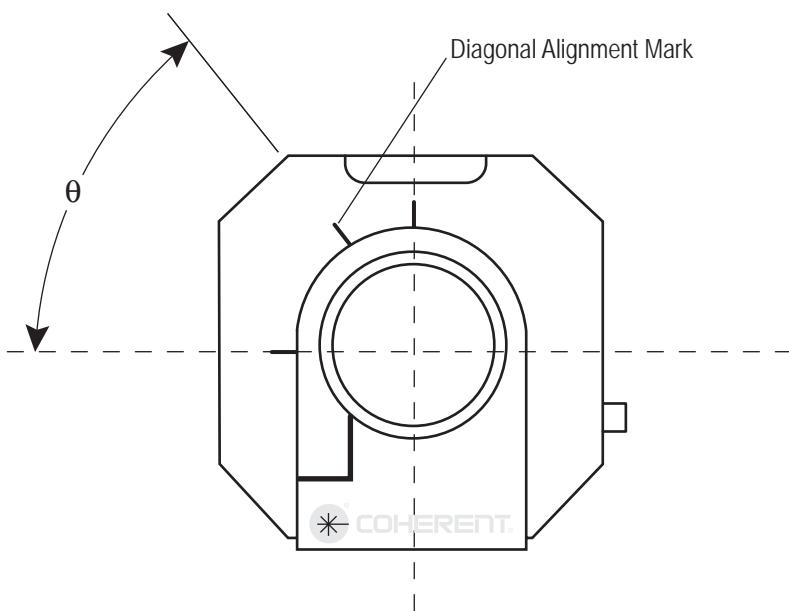


**Figure 3. Trigger Input and Pass/Fail Output Cable**

## Mounting the Camera

LaserCam-HR is designed to be mounted in any rotational position (in Figure 4,  $\theta = 0$  to  $360^\circ$ ) with a  $1\frac{1}{4}$ -20 threaded mounting post (for mounting post location, see “Physical Dimensions” on page 25). Alignment marks permit the camera to be rotated and aligned with the vertical, horizontal, and diagonal orientation of the sensor. The diagonal alignment mark helps identify the maximum diagonal position of the sensor array. Depending on the mounting orientation of the camera, the diagonal alignment mark will be either  $38^\circ$  or  $52^\circ$  off-axis to account for the rectangular shape of the

sensor. Note that the beam movement on the camera will not match the beam movement on the monitor for all positions.



*Figure 4. Mounting Configurations*

# OPERATION

This section discusses the following topics:

- Pixel spacing (page 12)
- Power on (page 12)
- Warm-up time (page 12)
- Maximum power levels (page 13)
- Saturation (page 13)
- Trigger (page 13)
- Low Distortion Face Plate (LDFP) (page 14)
- Dust/dirt (page 15)
- Cleaning the sensor (page 15)
- Fringes (page 16)
- How to get the most from your LaserCam-HR system (page 17)

## ***Pixel Spacing***

The LaserCam-HR pixel spacing values are shown in Table 2.

***Table 2. Pixel Spacing for LaserCam-HR***

<b><math>\frac{2}{3}</math>-INCH FORMAT</b>		
	Horizontal Spacing	Vertical Spacing
LaserCam-HR	6.70 $\mu\text{m}$	6.70 $\mu\text{m}$

## ***Power On***

LaserCam-HR has no ON/OFF switch. As soon as power is applied to the camera via the USB 2.0 connection, it begins operating.

## ***Warm-Up Time***

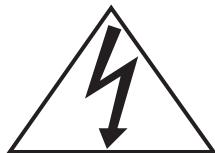
The LaserCam-HR does not require warm-up. However, if it is used to make high-accuracy measurements, it should be allowed to warm-up at least 15 minutes to insure best baseline (background) stability.

---

**For best results, the background map should be taken after the camera warm-up period.**

---

## ***Maximum Power Levels***



The camera will saturate at approximately  $16.0 \mu\text{W}/\text{cm}^2$  at 633 nm wavelength,  $320.0 \mu\text{W}/\text{cm}^2$  at  $1.06 \mu\text{m}$  wavelength, or  $3.2 \mu\text{J}/\text{cm}^2$  pulsed  $1.06 \mu\text{m}$  wavelength.

---

**Damage may occur at power levels that exceed 10,000 times saturation power density.**

---

## ***Saturation***

***Table 3. Saturation***

WAVELENGTH	ON ARRAY	ON LDFFP
633 nm (CW)	$16.0 \mu\text{W}/\text{cm}^2$	$40.0 \text{ mW}/\text{cm}^2$
1064 nm (CW)	$320.0 \mu\text{W}/\text{cm}^2$	$800.0 \text{ mW}/\text{cm}^2$
1064 nm (Pulse)	$3.2 \mu\text{J}/\text{cm}^2$	$8.0 \text{ mJ}/\text{cm}^2$

## ***Trigger***

The LaserCam-HR trigger permits the beam diagnostic system to interface with pulsed lasers and transient optical events, including single shot lasers.

### **Trigger In**

Trigger In uses the BNC connector labeled “IN” on the LaserCam-HR Trigger and Pass/Fail cable. This 5 VDC, TTL input—available on the rising or falling edge—causes the camera to immediately reset and begin

integrating light. The Trigger In delay is 150  $\mu\text{S}$ . This is the time it takes for the camera to begin integrating light once the trigger signal occurs. The LaserCam-HR is capable of sampling laser pulse repetition rates of up to 100 Hz without averaging adjacent pulses.

## **Trigger Out**

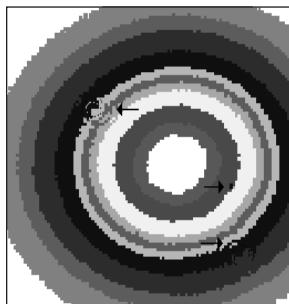
Trigger Out has been eliminated on this version of LaserCam. Coherent suggests that an external pulse generator be used if the laser under test does not supply a “sync-out” signal. Connect the pulse generator to the Trigger In connector. A delayed trigger should be applied to the Enable or Trigger input connector of the laser. Keep in mind that integration begins 150  $\mu\text{S}$  after the rising edge of the camera trigger (Trigger In), so you must delay the laser enable pulse by 150  $\mu\text{S}$ , minus any delay in the laser firing circuit.

## ***Low Distortion Faceplate (LDFP)***

The Low Distortion Faceplate provides a protective window for the camera array that also acts as a background attenuator with 0.04% to 0.05% typical. The LDFP is made of laser grade filter glass that minimizes interference fringes (refer to “Fringes” on page 16) and does not distort the beam image. The LDFP limits room light, instrumentation lights, and flash lamp light from reaching the camera sensor. These lights cause a background level that may not be effectively subtracted by the Background Subtraction Wizard.

## Dust/Dirt

If low intensity spots or small circles are noticed in the camera video then dust may be present on the CMOS sensor or on the Low Distortion Faceplate (see Figure 5 on page 15). Dust on the LDFP filter glass can cause distortion in the form of small circular diffraction rings, or can cause low-intensity spots if present on the sensor array. Observe the defects with a flashlight or a small light illuminating the camera. If the defect moves when the illumination angle is changed, then the dust is on the LDFP. Otherwise it is dust on the sensor array. Use clean air at low pressure, or methanol and lens tissue to clean the LDFP filter glass. Take all necessary precautions to insure that nothing comes in contact with the sensor surface.



**Figure 5. Dust on Filter Glass**

## Cleaning the Sensor

Avoid unnecessary exposure of the sensor to dust and dirt. If the surface of the sensor has to be cleaned, *never* use any kind of cloth, tissue, or brush, and strictly avoid the use of any kind of cleaning fluid. Only use clean, dry, micro-filtered low-pressure air to gently blow away particles from the surface of the sensor. Contact

Coherent Customer Service if the sensor requires additional cleaning (refer to “Coherent Service Centers” on page 23 for contact information).



**Touching the sensor will cause irreversible damage.**

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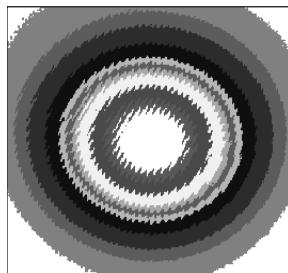
**Always cover the sensor with a dust cap when not in use.**

---

## *Fringes*

If the LDFP filter glass is installed in the camera, fringes may appear in the video (see Figure 6). The fringe pattern is due to a second reflection off the sensor and LDFP superimposing back onto the original beam image. This situation can be corrected by loosening the C-mount

setscrew and rotating the LDFP housing until the fringes are no longer present. Slightly turning the camera with respect to the laser beam may also reduce this effect.



*Figure 6. Fringes*

## ***How to Get the Most From Your LaserCam-HR System***

The LaserCam-HR has been carefully designed to provide accurate measurements of the spatial and intensity characteristics of laser beams. Significant attention has been paid to every aspect of the instrument that impacts data accuracy. The following items will help you obtain the best performance from your LaserCam-HR:

- System tray—Turn off everything that is non-essential to the running of the computer. This action will help assure the fastest frame update rate possible.
- Resolution—Select 640 x 512 x 8 resolution to obtain the highest update rates.
- RAM—A minimum of 512 MB is required. 1 GB is recommended. More is typically better.
- Select RAM for the buffer to obtain the highest update rates.

- Processor speed—A minimum of 3.3 GHz is recommended. Faster clock speeds provide higher frame update rates. Again, “the faster the better.”
- Keep all optics clean—Dirty LDFFP, beam sampling, and attenuation optics will distort the beam under test. It is important that you regularly check these optical surfaces for dust, fingerprints, and other contamination. Follow standard coated optical surfaces cleaning techniques. Use the Inclusion command to reduce the size and amount of data that is processed.
- The Inclusion command provides control of the sensor area where calculations are performed. Reducing this area can significantly increase frame update rates and is especially effective with small spot sizes.



---

**Cleaning the sensor surface will void the warranty and most likely will damage the camera.**

---

It is strongly recommended that the LDFFP always be left in place and that the dust cap be used to protect the LDFFP when the instrument is not in use.

- Read the user documentation—The LaserCam-HR is a complex piece of optical test equipment. Many functions are included in the system that may not be obvious to a casual or first-time user. Review the *LaserCam-HR User Manual* (this manual) and the BeamView-USB Help (accessed by clicking the Help button in the BeamView software) to learn about these useful functions. Many calcula-

tions and functions that may at first appear to require post-processing or exporting of the data to another application are included in the instrument. The user documentation is designed to explain all of the functions in an easy-to-use format.



---

**Observe standard Laser Safety procedures—The eyes you save may be your own.**

---



# WARRANTY

This section includes information on the following topics:

- Limited warranty (this page)
- Warranty limitations (page 22)
- Obtaining service (page 22)
- Product shipping instructions (page 24)

## *Limited Warranty*

Coherent, Inc. (the “Company”) warrants its laser beam diagnostic products (“Products”) to the original purchaser (the “Customer”) that the product is free from defects in materials and workmanship and complies with all specifications, active at the time of purchase, for a period of twelve (12) months.

If the Product fails and is returned to the Company within one year following the date of purchase, the Company will, at its option, repair or replace the Product or any component found to be defective. This warranty applies only to the original purchaser and is not transferable.

Coherent, Inc. will, at its option, repair or replace any product or component found to be defective during the warranty period. This warranty applies only to the original purchaser and is not transferable.

## ***Warranty Limitations***

The foregoing warranties shall not apply, and Coherent reserves the right to refuse warranty service, should malfunction or failure result from:

- Damage caused by improper installation, handling, or use.
- Laser damage (including sensor elements damaged beyond repair).
- Failure to follow recommended maintenance procedures.
- Unauthorized product modification or repair.
- Operation outside the environmental specifications of the product.

Coherent assumes no liability for Customer-supplied material returned with Products for warranty service or recalibration.

THIS WARRANTY IS EXCLUSIVE IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, ORAL, OR IMPLIED. COHERENT SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL THE COMPANY BE LIABLE FOR ANY INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS PRODUCTS.

## ***Obtaining Service***

In order to obtain service under this warranty, Customer must notify the Company of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. The Company

shall, in its sole discretion, determine whether to perform warranty service at the Customer's facility, at the Company's facility or at an authorized repair station.

If Customer is directed by the Company to ship the product to the Company or a repair station, Customer shall package the product (to protect from damage during shipping) and ship it to the address specified by the Company, shipping prepaid. The Company shall pay the cost of shipping the Product back to the Customer in conjunction with product failures within the first twelve months of time of sale.

A Returned Material Authorization number (RMA) assigned by the Company must be included on the outside of all shipping packages and containers. Items returned without an RMA number are subject to return to the sender.

For the latest Customer Service information, refer to our website: [www.Coherent.com](http://www.Coherent.com).

Detailed instructions on how to prepare a product for shipping are shown under "Product Shipping Instructions" on page 24.

***Table 4. Coherent Service Centers***

LOCATION	PHONE	FAX	E-MAIL
USA	1.800.343.4912	503.454.5777	info_service@Coherent.com
Europe	+49-6071-968-0	+49-6071-968-499	info_service@Coherent.com
International	503.454.5700	503.454.5777	info_service@Coherent.com

**Product  
Shipping  
Instructions**

To prepare the product for shipping to Coherent:

1. Contact Coherent Customer Service (refer to Table 4 on page 23) for a Return Material Authorization number.
2. Attach a tag to the product that includes the name and address of the owner, the person to contact, the serial number, and the RMA number you received from Coherent Customer Service.
3. Wrap the product with polyethylene sheeting or equivalent material.
4. If the original packing material and carton are not available, obtain a corrugated cardboard shipping carton with inside dimensions that are at least 6 in. (15 cm) taller, wider, and deeper than the product. The shipping carton must be constructed of cardboard with a minimum of 375 lb. (170 kg) test strength. Cushion the instrument in the shipping carton with packing material or urethane foam on all sides between the carton and the product. Allow 3 in. (7.5 cm) on all sides, top, and bottom.
5. Seal the shipping carton with shipping tape or an industrial stapler.
6. Ship the product to:

Coherent, Inc.  
27650 SW 95th Ave.  
Wilsonville, OR 97070  
*Attn: RMA # (add the RMA number you received  
from Coherent Customer Service)*

# APPENDIX A: SPECIFICATIONS

Table 5 lists specifications for the LaserCam-HR.

**Table 5. Specifications (Sheet 1 of 3)**

PARAMETER	DESCRIPTION
<b>GENERAL</b>	
<b>Physical Dimensions</b> <p>Physical Dimensions</p> <p>Front View Dimensions:</p> <ul style="list-style-type: none"> <li>Height: 34.0 mm</li> <li>Width: 34.0 mm</li> <li>Depth: 45.3 mm</li> <li>Lens Diameter: 68.1 mm</li> <li>Body Width: 36.6 mm</li> <li>Mounting Holes: 8-32 16.9 mm</li> </ul> <p>Side View Dimensions:</p> <ul style="list-style-type: none"> <li>Height: 79.3 mm</li> <li>Width: 40.9 mm</li> <li>Depth: 26.9 mm</li> </ul> <p>Callout Annotations:</p> <ul style="list-style-type: none"> <li>4.1 mm from housing face to element face locating surface</li> <li>17.8 mm from LDFP to element face locating surface</li> </ul> <p>Inset View Dimensions:</p> <ul style="list-style-type: none"> <li>Height: 14.0 mm</li> <li>Width: 23.0 mm</li> </ul>	

**Table 5. Specifications (Sheet 2 of 3)**

PARAMETER	DESCRIPTION
Spectral Range	$\frac{2}{3}$ -inch: Silicon, 300 to 1100 nm (400 to 1100 nm with LDFP)
Camera Type	Progressive scanning CMOS
Video Format	10-bit digital USB 2.0 hi-speed
Sensor Active Area	8.5 mm (H) x 6.8 mm (V) ( $\frac{2}{3}$ -inch format)
Sensor Elements	1280 (H) x 1024 (V)
Sensor Element Spacing	6.70 $\mu\text{m}$ (H) x 6.70 $\mu\text{m}$ (V)
Recommended Beam Diam.	0.20 mm min., 6.0 mm max. ( $1/e^2$ )
Optical Dynamic Range	> 1000 to 1
Dimensional Accuracy	$\pm 1\%$ (typical), $\pm 5\%$ (over entire spectral and dimensional range)
Pulse Trigger In	TTL, rising or falling edge
Pulse Integration Timing	Integration begins 150 $\mu\text{s}$ after rising edge of Trigger In
Automatic Pulse Trigger	0 to 100% of camera peak response (user adjustable)
Max. Sample Rate	15 Hz (Live mode), 10 Hz (Run mode)
Noise, Peak	24 nW/cm <sup>2</sup> (at 632.8 nm)
CW Saturation	40 mW/cm <sup>2</sup> (at 632.8 nm) (with LDFP)
Pulsed Saturation	8 mJ/cm <sup>2</sup> (at 1.06 $\mu\text{m}$ ) (with LDFP)
Damage Threshold	32 mJ/cm <sup>2</sup> (at 1.06 $\mu\text{m}$ ) (without LDFP)
Distance to Image Plane	$17.8 \pm 0.5$ mm (from front of LDFP)
Electronic Shutter	10 ms

**Table 5. Specifications (Sheet 3 of 3)**

<b>PARAMETER</b>	<b>DESCRIPTION</b>
Weight	208 g, 235 g with cable
Lens Mount	C-mount
Threaded Mounting Post	$\frac{1}{4}$ -20 Optional M6 post available (part #1086828)
I/O Connector	USB 2.0 Type B
<b>ELECTRICAL</b>	
Signal-to-Noise Ratio	> 60dB (gain 0 dB, gamma 1.0)
Power	Powered through USB 2.0 interface
Video Output	Digital: USB 2.0
Black Level	Self-adjusting
Exposure Time	Set to 10 ms, no user adjustment
Synchronization	Internal free-running (crystal)
Gamma	1.0
Gain	No automatic gain control. Gain is factory set for optimum linear dynamic range.
<b>ENVIRONMENTAL</b>	
Operating Temperature	-20 to 60°C
Relative Humidity	To 95% non-condensing





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